Mars Ecopoiesis Test Bed

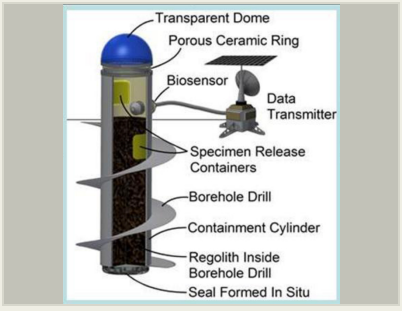
Completed Technology Project (2014 - 2015)

Project Introduction

Ecopoiesis is the concept of initiating life in a new place; more precisely, the creation of an ecosystem capable of supporting life. It is the concept of initiating "terraforming" using physical, chemical and biological means including the introduction of ecosystem-building pioneer organisms. The proposed concept will be subjected to extensive laboratory testing directed toward the ultimate emplacement of a test bed on (in) the surface of Mars to test (demonstrate) the activity of pioneer organisms selected on the basis of research on earth. To achieve this a device is proposed to penetrate and surround a sample of Martian regolith at a carefully selected site likely to experience transients of liquid water, completely seal itself to avoid planetary contamination, release carefully selected earth organisms (extremophiles like certain cyanobacteria), sense the presence or absence of a metabolic product (like O2), and report to a Mars-orbiting relay satellite. This will be the first major leap from laboratory studies into the implementation of experimental (as opposed to analytical) planetary in-situ research of greatest interest to planetary biology, ecopoiesis and terraforming.

Anticipated Benefits

A Mars Ecopoiesis Test Bed concept is proposed for development in a three-phase program concluding with a device for studying the survival of terrestrial life forms on the surface of Mars prior to abiological planetary engineering. Ecopoiesis is the concept of initiating life in a new place; more precisely, the creation of an ecosystem capable of supporting life. It is the concept of initiating terraforming using physical, chemical and biological means including the introduction of ecosystem-building pioneer organisms. This will be the first major leap from laboratory studies into the implementation of experimental (as opposed to analytical) planetary in-situ research of greatest interest to planetary biology, ecopoiesis and terraforming.



Concept diagram

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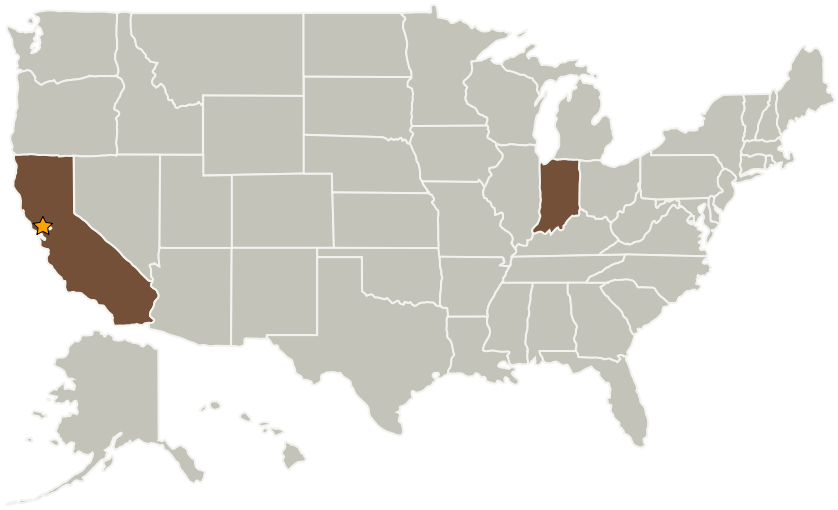
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California
Techshot, Inc.	Supporting Organization	Industry	Greenville, Indiana

Primary U.S. Work Locations	
California	Indiana

Project Transitions

July 2014: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

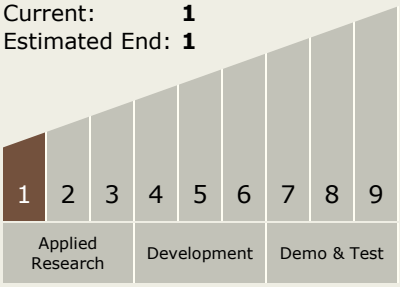
Eric A Eberly

Principal Investigator:

Eugene D Boland

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **1**



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June 2015: Closed out

Closeout Summary: Mars surface conditions where liquid water is absent were simulated for the purposes of laboratory research. A pressure-temperature (P-T) profile was maintained in which no combination of pressure or temperature corr esponds to the liquid region of the water phase diagram. The triple point of pure water occurs at T = 0.1oC and P(H2O) = 6.01 mbar; therefore all temperatures and pressures must be kept below these values, respectively. A 35-day test was performed in a commercial planetary simulation system (Techshot, Inc., Greenvi lle, IN) in which the minimum night-time temperature was -80oC, the maximum daytime temperature was +26oC, the simulated day-night light cycle in earth ho urs was 12-on and 12-off, and the total pressure of the pure CO2 atmosphere w as maintained below 11 mbar. Any water present was allowed to equilibrate with the changing temperature and pressure. The gas phase was sampled into a CR1 -A condensation-mirror low-pressure hygrometer, which uses liquid nitrogen (do wn to 77oK) to determine the dew point (Buck Technologies, Boulder, CO). Dew point was measured once every hour and recorded on a data logger, along with the varying temperature in the chamber, from which the partial pressure of wat er was calculated. The resulting calculated daily cycles were tracked on the wate r P-T diagram, and no points were found to fall within the liquid-phase region of the diagram. It is concluded that there was no liquid water present throughout t he test except during the initial pump-down period when aqueous specimens we re introduced on the first day (less than 1 hour). Mars regolith simulant was pre sent during this test, and further investigation is needed to determine whether li quid water could have been present or absent in the regolith in the form of brin e. Biological samples consisting of Cyanobacteria: Anabena sp., Chroococcidiopsi s CCMEE171, Plectonema boryanum; Eubacteria: Bacillus subtilis, Pseudomonas aeruginosa, and Eukaryota: Chlorella ellipsoidia were maintained in the simulato r under the above-described conditions. The exposed specimens were tested for intracellular esterase activity, chlorophyll content (where appropriate) and repro ductive survival. All tests yielded low-level positive results in all cases. In paralle l to these terrestrial studies a planned design study was undertaken for the prop osed test bed . Design requirements include compact assembly for transport and installation on the planetary surface (multiple units per mission would be expect ed), protective internal package for the release of organisms, a means of atmos phere exchange, access to sunlight, a means of penetrating the planetary surfac e, and most importantly a means of acquiring regolith while meeting the require ments of planetary protection. In consultation with advisers a design was create d, and a large-scale mock-up of this design was fabricated by additive manufact uring at Techshot, Inc. with moving parts that simulated the components of the design. The mock-up assembly has been demonstrated to interested parties. A means of detecting live metabolism will also be included in the test bed. Several options were reviewed, and it is concluded that, by the time the ecopoiesis test bed is ready for testing the optimum instrument will be the equivalent of a hand -held mass spectrometer for metabolic gas analysis. This will maximize versatilit y and reveal much more information than could a detector of a single product (s uch as molecular oxygen), and the simple output signals will be compatible with telemetry. The objectives of this project, (1) Model and test the availability of liq uid water in Techshot's Mars simulator facility, (2) Identify current candidate pio neer organisms for testing and initiate a selection program, (3) Create a mecha nical and electronic design concept for Mars surface shallow penetrator with plan etary protection, and (4) Identify electronic biological activity tests, were fulfille d by the completion of the Phase-1 research described in this final report.

Technology Areas

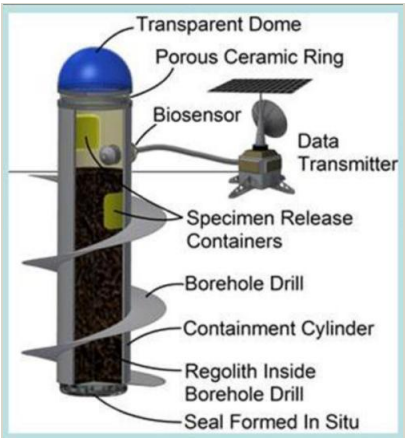
Primary:

- TX08 Sensors and Instruments
  - TX08.3 In-Situ Instruments and Sensors
    - TX08.3.3 Sample Handling

Target Destination

Mars

Images



Mars Ecopoiesis Test Bed Concept
Concept diagram
(https://techport.nasa.gov/image/102071)

Project Website:

https://www.nasa.gov/directorates/spacetech/home/index.html